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NAVAL SHIPS' TECHNICAL MANUAL

CHAPTER 502

AUXILIARY STEAM TURBINES

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CHAPTER 502

AUXILIARY STEAM TURBINES

SECTION 1.
INTRODUCTION

502-1.1 PURPOSE

502-1.1.1 This chapter supersedes and replaces that portion of **NSTM Chapter 9500, Auxiliary Steam Turbines,** documenting the noncondensing auxiliary steam turbines used to drive equipment such as main feed pumps, forced draft blowers, main circulating pumps, condensate pumps, booster pumps, fire pumps, fuel oil pumps, and main lube oil pumps. For information concerning turbines used to drive ship's service turbogenerators and for information concerning propulsion steam turbines, refer to **NSTM Chapter 231, Propulsion Turbines (Steam).** For additional forced draft blower information, refer to **NSTM Chapter 554, Forced Draft Blowers.** For information concerning the pump ends of the equipment listed above, refer to **NSTM Chapter 503, Pumps.**

502-1.2 SCOPE

502-1.2.1 This manual presents general principles of operation, maintenance, and repairs of auxiliary steam turbines on Navy ships. Because of the great variation in auxiliary turbines, detailed instructions and procedures cannot be given in this text. Details of auxiliary steam turbines, including safety precautions, detailed descriptions, installation, operation, troubleshooting, maintenance, and repair information can be found in equipment technical manuals specified for each unit. Along with the information contained in this chapter and equipment technical manuals, the following documentation should be used:

a. Engineering Operational Sequencing System (EOSS). The EOSS procedure for each unit must be utilized during all phases of the auxiliary turbine operation.

b. Planned Maintenance System (PMS). The PMS procedure for each unit is designed to keep the units operating in a safe, efficient, and reliable manner.

c. Technical Repair Standard (TRS). The TRS and detail drawings for each unit should be followed during the repair or overhaul of the unit.

502-1.2.2 Information contained in this chapter should be followed in the absence of applicable EOSS procedures, PMS procedures, or equipment technical manuals. If deficiencies are found in this chapter or the equipment technical manuals, the Naval Sea Systems Command (NAVSEA) or Naval Ship Systems Engineering Station (NAVSSES) should be notified via a Technical Manual Deficiency/Evaluation Report (TMDER) to reconcile differences.

502-1.3 STEAM TURBINE DEFINITIONS

502-1.3.1 A steam turbine is defined as a prime mover that converts the thermal energy of steam directly into mechanical energy. The energy conversions occur in the following two steps:

a. Steam passes through the turbine nozzles and expands, discharging at a high velocity. This process converts the available heat energy into velocity energy (kinetic energy).

b. High velocity steam hits the moving blades converting the kinetic energy into mechanical work.

502-1.3.2 The steam consumption of an auxiliary steam turbine can be expressed as either steam rate or as steam flow. Steam rate is defined as pounds of steam per horsepower per hour, while steam flow is defined as pounds of steam per hour. In equipment technical manuals, steam consumption for an auxiliary turbine is generally stated in terms of steam flow (pounds of steam per hour (lbs/hr)).

502-1.4 GENERAL INFORMATION

502-1.4.1 Auxiliary steam turbines are used to drive many auxiliary units on board Navy ships. Turbine driven auxiliaries in use on board Navy ships include main feed pumps, feed booster pumps, lube oil service pumps, fuel oil service pumps, fire pumps, main condensate pumps, main circulating pumps, and forced draft blowers. Some of the turbine driven auxiliaries are duplicated by electric driven units. The electric driven units have comparatively high efficiencies, but their capacities are not always sufficient to meet the demands of the engineering plant at full power conditions.

502-1.4.2 One advantage of an auxiliary steam turbine as a prime mover over an electric unit is that there is a far greater probability that electric power interruptions will occur than steam supply interruptions. Therefore turbine driven units such as fire pumps, feed pumps, and forced draft blowers can operate during critical periods when electrical power is interrupted. Another advantage of auxiliary steam turbines is that they can operate at variable speeds without the need for speed changing devices. As a result, the overall efficiency of a turbine driven pump can be optimized by reducing the speed of the pump rather than throttling the pump. Even though the turbine efficiency will decrease as the turbine speed is reduced, the steam consumption of the turbine will be less than if the pump were throttled.

502-1.5 GENERAL SAFETY PRECAUTION

502-1.5.1 The following list contains general safety precautions and tests that, if observed and performed in accordance with PMS and EOSS procedures, will help ensure that an auxiliary turbine operates safely and efficiently.

a. Turn turbine by hand daily and before admitting steam to casing.

b. Do not lash down an overspeed trip nor a speed-limiting governor, nor take other steps to render them inoperative.

c. Keep the exhaust casing relief valve set at the proper pressure and in operating condition at all times. Test by hand before admitting steam to casing.

d. Keep the oil reservoir properly filled with clean oil at all times.

e. Before starting turbine, inspect to see that it is clear of foreign matter, especially if the unit has not been operated for a long period.

f. Keep the unit properly balanced at all times.

g. Avoid water hammer by properly draining lines and opening valves slowly.

h. Before turbine is put in service, test the electronic overspeed trip and/or hand trip and low suction trip if provided. Do not test overspeed trips by overspeeding the turbine.

i. Test the speed-limiting governor before putting turbine in service.

j. Avoid passing steam through a turbine with the rotor at rest.

k. Keep the governor operating mechanism and regulating valve stems clean and free from corrosion and the cylinder insulation well clear of the steamchest lift rods.

l. Keep bearing oil pressure within specified range.

m. Keep oil strainer clean.

n. Keep oil cooler clean.

o. Operate relief valves by hand.

p. =

p. Clean steam strainer.

q. Check condition and clearances of thrust and sleeve bearings, where accessible.

r. Check gland packing for wear.

502-1.5.2 For specific safety precautions and warnings concerning particular auxiliary steam turbines, consult the applicable equipment technical manual. All safety precautions and warnings should be strictly adhered to when working on and operating auxiliary steam turbines.

SECTION 2.

AUXILIARY TURBINE CLASSIFICATION

502-2.1 GENERAL INFORMATION

502-2.1.1 In general, turbines in Naval service may be classified as follows:

a. Speed: constant or variable

b. Exhaust conditions: condensing units which exhaust steam at less than atmospheric pressure and noncondensing units which exhaust steam at higher than atmosphere pressure

c. Shaft position: horizontal, vertical, or inclined

d. Type: Impulse, reaction, or a combination of impulse and reaction

e. Direction of steam flow: axial, radial, or tangential re-entry (helical)

f. Stages: single or multiple

g. Drive: direct or geared

h. Service: based on driven auxiliary

i. Navy classification: power output capacity; limiting speeds, and similar data.

502-2.1.2 Auxiliary turbines are normally axial, radial, or tangential (helical) flow, single stage, impulse type noncondensing units. The units usually operate at back pressure of approximately 15 lb/in^2 g, depending on auxiliary exhaust line pressure.

502-2.2 IMPULSE TURBINES

502-2.2.1 An impulse turbine is one in which steam under pressure enters a stationary nozzle where its pressure is converted into velocity (kinetic) energy and directed towards the blades of the rotor where the kinetic energy is converted to mechanical energy, forcing the rotor to rotate. The impulse stage includes the nozzles and blading in which only one pressure drop occurs. A simple impulse stage is also called a Rateau stage.

502-2.2.2 A velocity-compounded impulse turbine is used to increase efficiency by adding one or more rows of moving blades. The steam leaving the first row of moving blades is directed through a stationary set of blades and enters the second row of moving blades where the remaining steam velocity (kinetic energy) is utilized. If a third row is added, the (kinetic energy) velocity of the steam leaving the second row is utilized in the third row. The velocity-compounded impulse turbine has only one pressure drop and therefore by definition has only one stage. This type of velocity-compounded impulse stage is also called a Curtis stage.

502-2.3 DIRECTION OF STEAM FLOW

502-2.3.1 Steam flow through Navy auxiliary turbines can be classified as axial, radial, or helical.

a. Axial Flow: the direction of steam flow is approximately parallel to the turbine shaft
b. Radial Flow: the direction of steam flow is radially toward the axis of the turbine shaft
c. Helical Flow: the steam enters at a tangent to the outer edge of the rotor and impinges on the moving blades of the turbine.

502-2.4 SINGLE/MULTIPLE STAGE TURBINES

502-2.4.1 Turbines can be classified as either single- or multiple-stage turbines. In a single-stage turbine (see Figure 502-2-1), the conversion of (kinetic energy) velocity energy to mechanical work occurs with a single expansion of steam in the turbine. The expansion of the steam through the turbine nozzles results in a pressure drop. Therefore, a single-stage turbine can be defined as a unit in which only one pressure drop occurs within the turbine. A multiple-stage turbine is one in which the conversion of energy occurs with two or more expansions of the steam within the turbine. Therefore a multiple stage turbine is one in which two or more pressure drops occur within the turbine.

502-2.5 TURBINE DRIVE

502-2.5.1 Auxiliary turbines can also be classified according to type of drive. A direct-connected turbine is one that is directly connected to the driven unit by either a solid shaft or some type of coupling. As a result, the auxiliary turbine and the driven unit shaft speeds are the same. A geared turbine is one which drives the driven unit through a speed reduction (or speed increasing) gear. Thus the auxiliary turbine can operate at a different speed from the driven unit. This will permit the turbine and the driven unit to operate at their most efficient speeds.

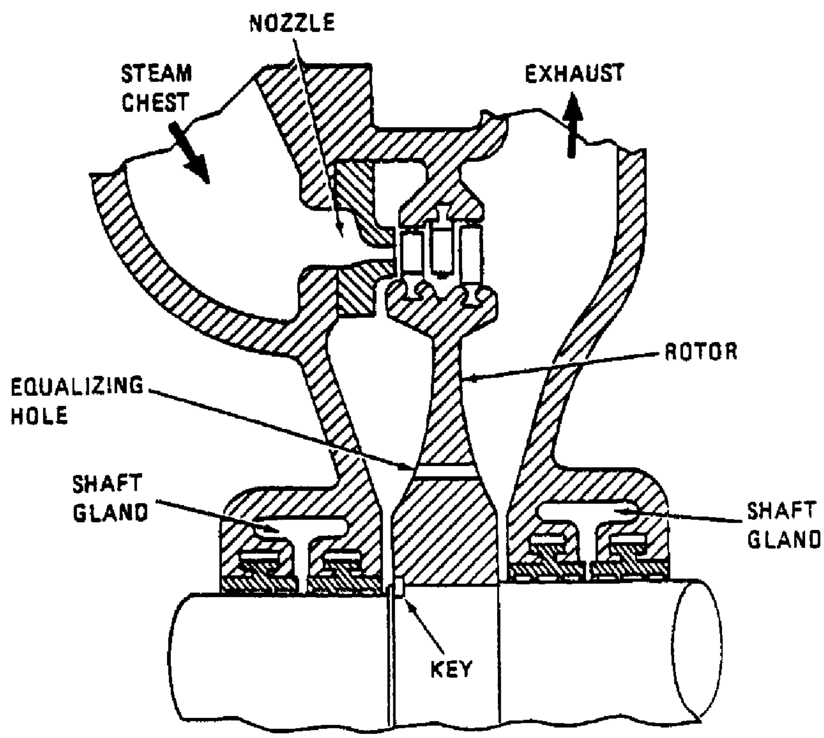

Figure 502-2-1 Single-Stage Turbine (Curtis Stage)

SECTION 3.

OPERATION

502-3.1 GENERAL INFORMATION

502-3.1.1 A turbine first put into service is subject to variable expansion due to the changing conditions of load and consequent changes in internal pressure and temperature. The foundation of the turbine is also subject to thermal growth and requires time to accommodate itself to service conditions. Therefore, a reasonable amount of time should be spent in warming up the turbine. The turbine should be operated at a minimum speed until the lube oil reaches the temperature specified in the applicable equipment technical manual or Engineering Operational Sequencing System (EOSS) procedures. No definite time is specified to warm up turbines, as this depends upon the individual machine. If the instructions of the equipment technical manual, EOSS procedures, and those specified in this chapter are carefully observed, successful turbine operation should result.

502-3.2 STARTING AUXILIARY TURBINES

502-3.2.1 EOSS procedures for each particular unit must be utilized when starting auxiliary turbines. The following are general steps used when starting noncondensing auxiliary turbines, and should be used in conjunction with EOSS procedures and equipment technical manuals for each particular unit:

1. Ensure that the turbine is free of all foreign matter such as tools, rags, and bolts.
2. Ensure that all working parts are clean and well oiled. Test the relief valve, governor valve linkage, and other safety devices by hand where practical.

3. Ensure that the lube oil level in the sump is at the MAX mark on the dipstick. This allows for the drop in oil level due to the oil which fills the system when the unit is started.

4. Rotate the unit by hand where practical using a strap wrench or other suitable means. It should rotate easily and without noise or grinding of any kind.

5. If a stop valve is provided in the exhaust line, be sure the valve is open before the steam inlet valves are touched. If the exhaust valve is of the spring loaded type (combined exhaust relief valve), do not open it at this time. If provided, bring auxiliary gland exhaust leak-off system on line to the turbine.

6. Drain the turbine casing and the steam inlet line to the turbine throttle valve. This must be done carefully and thoroughly. The steam inlet line between the turbine throttle and root valve may contain water; therefore, it should be drained before opening the root valve. If the line is not fitted with a drain, open the turbine throttle and allow water to drain into the turbine casing and out through the turbine drain. Then crack the root valve until steam shows in the turbine drain.

CAUTION

A sudden and large opening of the root valve may result in damage from water hammer and may cause injury to personnel.

7. Close throttle valve and open root valve.

8. Ensure that driven auxiliary is in proper operational condition. If a pump pressure regulating valve is installed in the steam line, ensure that it is in operating condition.

9. If the exhaust valve is a combination exhaust relief valve, open it at this time.
   a. If the exhaust valve is spring loaded, do not open it at this time. (Refer to step 16.)
   b. Crack the throttle valve and spin the rotor.

CAUTION

Do NOT warm up auxiliary turbines by opening the exhaust valve to admit auxiliary exhaust steam.

10. On turbines with force feed lubrication, check lube oil pressure gauge and sight flows to ensure that the bearings are getting oil. On turbines with oil ring lubrication and inspection openings, ensure that the rings are revolving.

11. Ensure that no rubbing sounds due to the rotor exist.

12. Check exhaust pressure and ensure that it is between 15 and 20 lb/in^2 g. If pressure is excessive, stop the turbine immediately and remedy the problem before attempting to restart the unit.

13. If exhaust pressure is satisfactory, run turbine at minimum speed until lube oil from the cooler reaches normal operating temperature (48.9 to 54.4° C (120 to 130° F)). If an automatic lube temperature control valve is installed, this will occur automatically. If a four-way cock is installed, turn cock to the bypass position until normal temperatures are reached and then return the cock to the cooler flow position. If neither of these features is installed, throttle the cooling water flow until normal temperatures are reached.

14. Close turbine drains when all condensate has completely drained (steam visible in drain).

15. During the warming and accelerating period, listen carefully for any rubbing, unusual noise, or vibration. If

any rubbing is detected, decrease speed until all evidence of it has disappeared. If the noise continues, secure the unit immediately and notify the engineering officer. Do not resume unit operation until the cause of the trouble has been identified and corrected.

NOTE

During the turbine warm-up period, ensure that the driven auxiliary is operating properly.

16. Some of the older auxiliary turbines have spring loaded exhaust relief valves. The valves can be operated or seated by hand, but cannot be positively closed by hand. They are designed to open automatically when the steam pressure in the turbine casing exceeds the pressure in the exhaust line by 2 lb/in^2 g. If provided, fully open the spring loaded exhaust valve by hand when the turbine has reached normal operating speed. Do not confuse these valves with the combination exhaust relief valve which was opened prior to cracking open the throttle valve. (Refer to step 9.)

17. If the auxiliary turbine has an emergency overspeed trip, operate the system by hand when the unit reaches its normal operating speed. MAKE SURE THE TRIP VALVE CLOSES. If the overspeed trip mechanism does not function properly, the turbine is NOT to be operated until the problem is corrected.

CAUTION

The overspeed trip mechanism should never be tested at actual trip speed.

18. After successfully demonstrating the emergency overspeed trip mechanism, reset the latch and bring the unit to the required operating speed. Give the unit a thorough trial under load conditions, paying attention to lubrication and governor action.

502-3.3 OPERATION OF AUXILIARY TURBINES

502-3.3.1 EOSS procedures for each particular unit must be utilized when starting auxiliary steam turbines. The following are general steps to be followed during the operation of auxiliary steam turbines. They should be observed in conjunction with EOSS procedures and equipment technical manuals for each particular unit.

1. When operating auxiliary turbines, lube oil temperature should be maintained between 48.9 and 54.4° C (120 and 130° F). If an automatic lube oil temperature control valve is installed, temperature will be maintained automatically. Otherwise, maintain temperature by regulating the flow of cooling water.

2. Ensure that the lube oil level in the sump is (normal) between the MAX and MIN marks on the dipstick, especially when starting the unit for the first time after filling.

3. The lube oil temperatures leaving the bearings should be approximately 65.6° C (150° F). Under no circumstances should the maximum lube oil temperature be allowed to exceed 82.2° C (180° F). Low temperatures under normal operating conditions should be avoided since the high velocity of excess cooling water through the cooler and pipes will cause erosion, thereby reducing the life of the equipment.

NOTE

The maximum temperature rise of lube oil passing through any bearing should not exceed 27.8° C (50° F).

4. Some auxiliary turbines have one hand-operated nozzle valve. The hand operated nozzle valve is used to permit normal full load to be carried with low steam pressure or high back pressure, or to permit an overload to be carried with normal steam conditions. Some of the older auxiliary turbines (such as forced draft blowers) are equipped with several hand-operated nozzle valves which may be opened or closed as load and steam conditions require. It is more economical to operate with one nozzle wide open than to operate with two nozzles partly open. Furthermore, to obtain best economy, a turbine should operate with as few nozzles in use as will give the required power when the throttle is wide open. For turbines with several hand-operated nozzle valves, small changes in output should be accomplished with the throttle, but large changes should be made by cutting nozzles in or out, i.e. always carry, as nearly as possible, full steam pressure in the chest.
5. Inspect the turbine for oil, steam, or water seepage and correct if found. The exterior of the turbines should be kept free from dust, oil, and water.

WARNING

To avoid possible fire hazard, all filter maintenance should be done with the turbine secured whenever possible. When maintenance must be done on a duplex strainer on an operating turbine, extreme care must be exercised to prevent spillage of pressurized oil.

6. For auxiliary turbines with a metal edge lube oil filter (Cuno or similar), the filter cleaning handle should be turned at least once each watch. Duplex oil strainers are also used on auxiliary steam turbines. Duplex strainers have two separate straining compartments, each with a removable clamp cover. A duplex three-way valve with an integral jack for lifting and tightening the valve plug is located between the compartments. Without interrupting flow, the oil flow can be transferred from one strainer to the other. While the oil is being strained through one basket, the other basket can be removed from its compartment for cleaning. For additional information concerning lube oil systems, refer to paragraphs 502-4.1 through 502-4.1.6.
7. When operating auxiliary turbines in a standby condition, extreme care shall be taken to assure that the unit is operating at sufficient speed to provide lubrication to all bearings. This is particularly important on vertical units where casualties to upper bearings can occur due to the lack of lubrication during standby operation.

502-3.4 SECURING AUXILIARY TURBINES

502-3.4.1 The following steps, along with EOSS procedures, should be used to secure auxiliary turbines:

1. Reduce load.
2. Close all hand-operated nozzle valves.
3. Manually trip the overspeed trip, if provided, to slow down the turbine.
4. Close throttle valve.
5. Close root steam valve.
6. Close exhaust valve.
7. Close lube oil cooling water valves when the lube oil reaches the temperature specified in the EOSS procedures.
8. Open all drain valves, allow condensate to drain completely.

9. When the turbine has cooled to ambient temperature and all condensate has drained from the turbine casing, close the high pressure drain valves.

NOTE

Leave low pressure drain valves open.

10. Secure the auxiliary gland exhaust leak-off system from the turbine (if provided).

502-3.5 OIL TEMPERATURES WHEN STARTING

502-3.5.1 Consult applicable EOSS procedures, Planned Maintenance System (PMS) procedures, or equipment technical manuals for proper lube oil temperatures when starting auxiliary turbines. If no information is available, the following points shall be observed in connection with oil temperatures when starting a turbine:

a. Units should not be started until the oil in the reservoir is at least 15.6° C (60° F). Oil below 15.6° C (60° F) shall be removed from the reservoir and heated in the purifier or settling tank before the unit is turned over.
b. If the lube oil temperature in the reservoir is between 15.6° and 37.8° C (60 and 100° F), the auxiliary lube oil pump should be operated until the reservoir temperature reaches 37.8° C (100° F). If no auxiliary lube oil pump exists, or if the auxiliary pump will not raise the oil temperature sufficiently, the unit should be operated slowly until the oil temperature to the bearings is 37.8° C (100° F). When the oil temperature reaches 37.8° C (100° F), the unit can be brought to normal operating speed.

502-3.5.2 For information relating to oils and lubrication, refer to**NSTM Chapter 262, Lubricating Oils, Greases, Specialty Lubricants, and Lubricating Systems.**

SECTION 4.

GENERAL DESCRIPTIONS

502-4.1 LUBE OIL SYSTEM GENERAL INFORMATION

502-4.1.1 GENERAL. The use of clean, pure lube oil is essential to the long life and successful operation of a turbine. The primary function of lube oil is to reduce friction, dissipate heat from the bearings, and prevent corrosion. The lube oil used in auxiliary steam turbines is 2190TEP, which is a series 2 oil with an approximate viscosity of 190SUS at 54.4° C (130° F). For specific information concerning lubricants, refer to **NSTM Chapter 262, Lubricating Oils, Greases, Specialty Lubricants, and Lubricating Systems.** It is essential that the lube oil pressure, temperature, and flow through the sight flows be continually monitored to ensure that the turbine is properly lubricated during startup and normal operation. Refer to the applicable Engineering Operational Sequencing System (EOSS) procedures, Planned Maintenance System (PMS) procedures, or equipment technical manuals for required lube oil pressures.

502-4.1.2 LUBE OIL FILTERS. On auxiliary turbines with pressure lubrication, an oil filter is usually provided in the oil line on the discharge side of the oil pump. The following filters are in use on various auxiliary turbines in the Fleet.

a. Metal Edge Filters (Cuno or similar type): Metal edge filters (see Figure 502-4-1) can be found in use on all types of auxiliary turbines. In an effort to standardize the lube oil system for main feed pumps and forced draft blowers, a Cuno filter will replace the original lube oil filters and strainers. The filter is capable of removing 40 micrometer (micron) particles and larger due to the wheel shaped disk configuration of the filter cartridge. This type of filter should be cleaned at least once each watch by rotating the handle two or three turns. An internal relief valve is installed and set to bypass oil if the differential pressure across the filter is excessive. At periodic intervals, the filter should be dismantled and cleaned in accordance with applicable PMS procedures.

b. Duplex Strainers: Duplex oil strainers (see Figure 502-4-2) have two separate straining compartments, each with a removable cover. A duplex threeway valve with an integral jack for lifting and tightening the valve plug is located between the compartments. Without interrupting flow, the oil flow can be transferred from one straining compartment and its basket to the other compartment and its basket. Each basket can be removed from its compartment for cleaning. The strainer baskets should be cleaned at regular intervals, care being taken to remove any metallic particles that may have adhered to the magnets in the strainer baskets.

WARNING

To avoid possible fire hazard, all filter maintenance should be done with the turbine secured whenever possible. When maintenance must be done on a duplex strainer on an operating turbine, extreme care must be exercised to prevent spillage of pressurized oil.

c. Some units have full flow filters installed with differential pressure gauges at the cartridges. These filters should be changed/cleaned when the pressure drop reaches an amount specified in the applicable PMS procedure or equipment technical manuals.

502-4.1.3 THERMOSTATIC CONTROL VALVE. Some main feed pumps and forced draft blowers are equipped with thermostatic control valves that will automatically maintain the lube oil system temperature at 48.9 to 54.4° C (120 to 130° F). The valve is installed in the piping to the lube oil cooler. At startup when the lube oil is cold, it will bypass the lube oil cooler. As the oil warms up, the thermostatic control valve will direct oil through the cooler and maintain the oil outlet temperature between 48.9 and 54.4° C (120 and 130° F). With a thermostatic control valve installed, the cooling water cutout valves at the cooler are fully open. The cooling water flows through the cooler and is controlled by an orifice installed in the outlet piping from the cooler. This valve will begin to open the cooler port at 48.9° F (120° F) and will be fully open if the oil temperature reaches 54.4° C (130° F); at intermediate points the temperature maintained will be a function of the heat load on the cooler. If the thermostat should fail to maintain the proper oil temperature, the element must be replaced. If no replacement is available, the element should be removed and the bypass port blanked. The lube oil temperature can then be maintained by manual regulation of cooling water flow through the cooler.

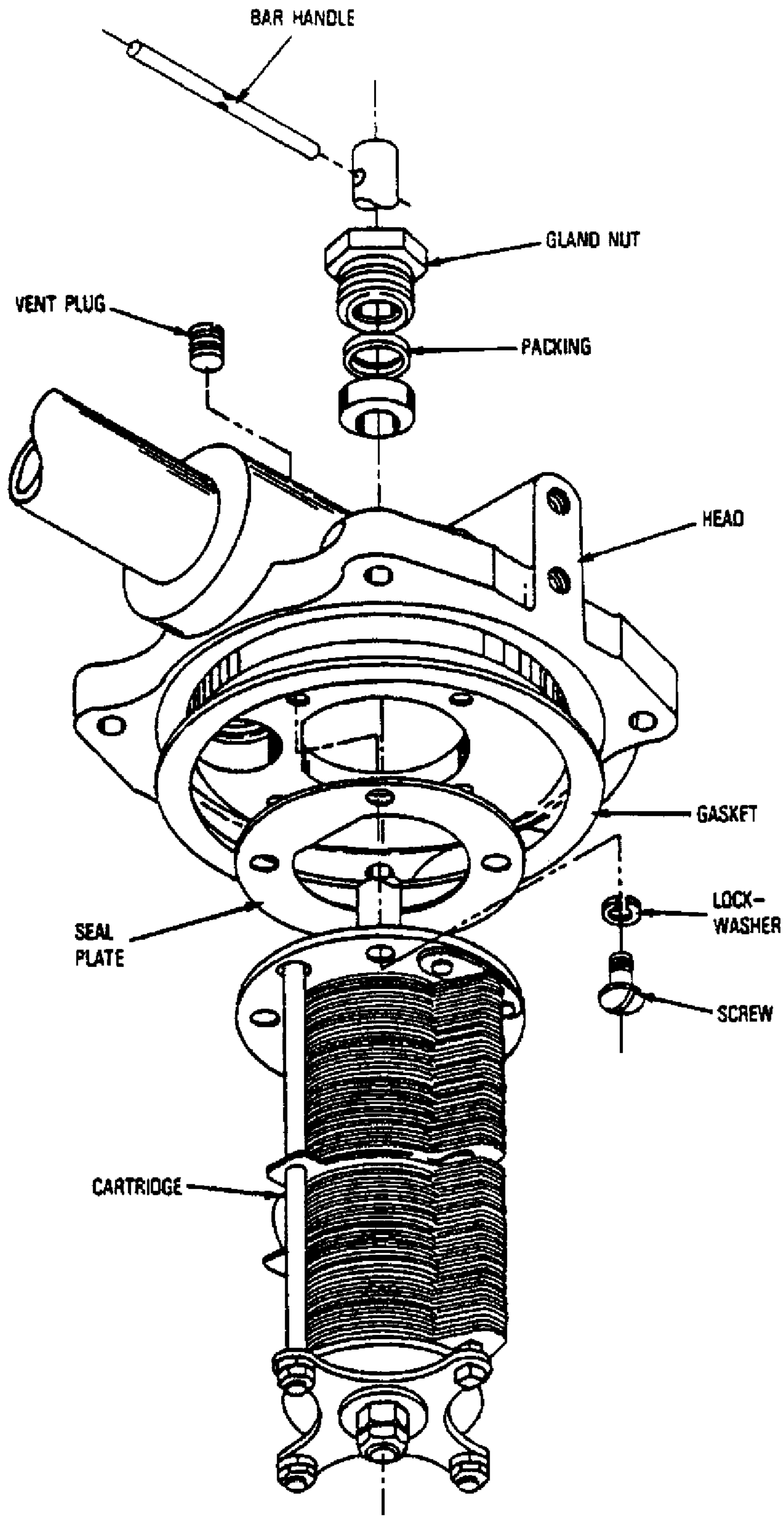

Figure 502-4-1 Metal Edge Filter

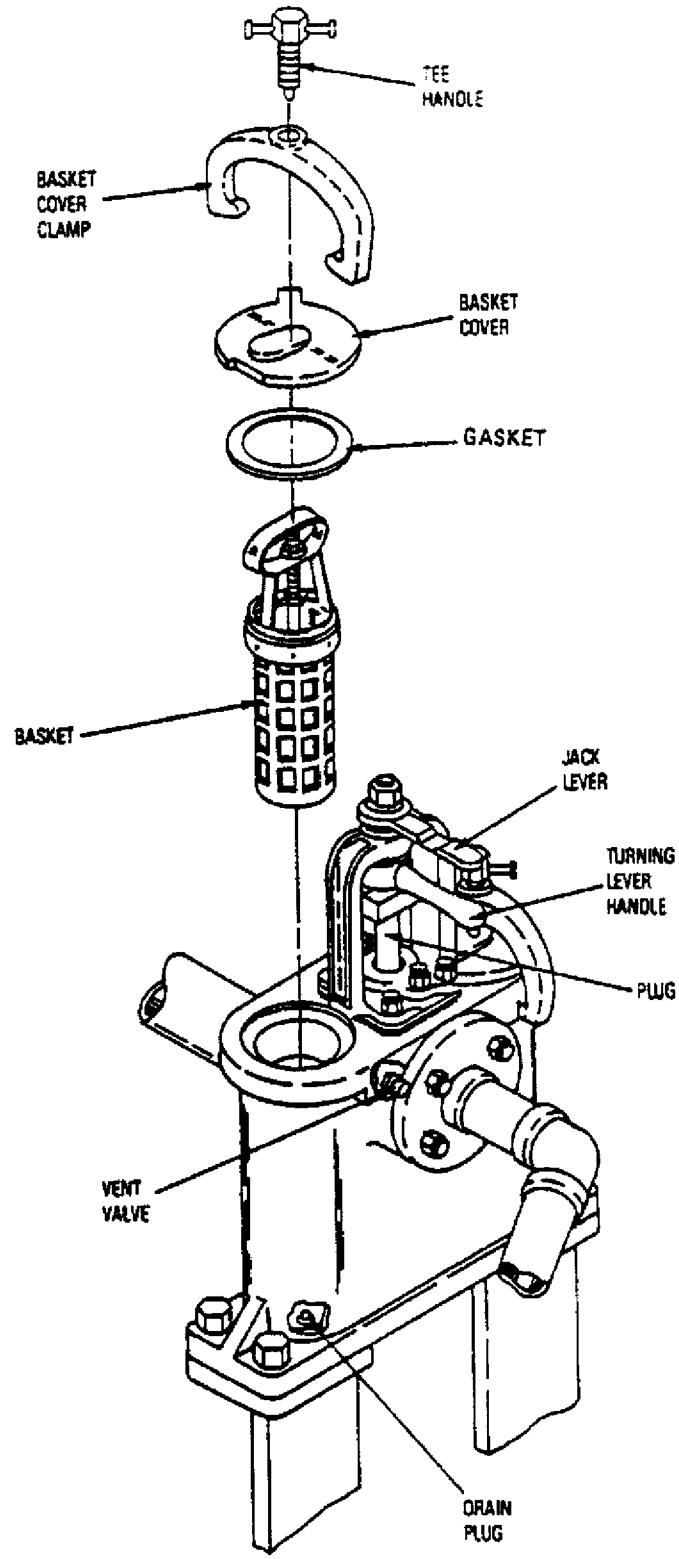

Figure 502-4-2 Duplex Strainer

502-4.1.4 CENTRIFUGAL SEPARATORS. Some auxiliary steam turbines are equipped with centrifugal separators. The centrifugal separators are designed to remove water and fine solid contaminants from the unit's lube oil system. For specific information concerning centrifugal separator operation, maintenance, or design characteristics, consult the applicable PMS procedures or equipment technical manuals.

502-4.1.5 LUBE OIL, REGULATING VALVES. A regulating valve is usually fitted in the lubricating system to regulate oil pressure to the bearings. If excessive oil flow to the bearings occurs, the bearing cavity will flood causing oil seal leakage. Clogged drain holes have the same effect. Consult the applicable equipment technical manuals or EOSS procedures for correct regulating valve settings.

502-4.1.6 LUBE OIL PUMPS. Auxiliary turbines in use on board Navy ships utilize their own lube oil pumps to supply oil to the bearings and governor. The pumps can be gear driven (attached), motor driven, or hand operated. The following paragraphs provide brief descriptions of the most common type of lube oil pumps found on auxiliary turbines.

502-4.1.6.1 Main Lube Oil Pump (Gear Driven). Almost every main lube oil pump utilized on auxiliary turbines is gear driven (attached). Generally the gears of the pump are connected to the lower end of the governor drive shaft and driven by the reduction gear from the main shaft. The pumps are designed to supply adequate oil pressure to the governor and bearings during normal operation. Some of the main oil pumps on forced draft blowers are reversing pumps. The pumps can be driven in either direction of rotation without a change in the direction of flow. This will ensure that the bearings are lubricated during windmilling of an idle blower. For specific information concerning main oil pump design or operation, refer to applicable EOSS procedures or equipment technical manuals.

502-4.1.6.2 Motor Driven Auxiliary Lube Oil Pumps. Auxiliary turbines used for main feed pumps and forced draft blowers are equipped with motor driven auxiliary lube oil pumps to supplement the attached lube oil pump during normal starting and stopping of the turbines. The pumps are usually positive displacement rotor pumps, and are not designed to match the required output of the attached lube oil pumps. Most of the auxiliary lube oil pumps on main feed pumps and forced draft blowers are equipped with automatic controls. The auxiliary oil pump must be started manually prior to starting the turbine. Auxiliary oil pumps have either automatic start/stop controls or automatic start/manual stop controls. With automatic start/stop controls, the auxiliary pump will automatically start when system oil pressure drops to a predetermined pressure and automatically stops when oil pressure rises to a predetermined pressure. With automatic start/manual stop controls, the auxiliary pump starts automatically on low pressure but must be manually stopped when acceptable system pressure is attained. For details concerning the auxiliary lube oil pump controls and operation, refer to the applicable EOSS procedures or equipment technical manual for the auxiliary turbine in question.

502-4.1.6.3 Hand-Operated Auxiliary Lube Oil Pumps. These pumps are hand operated by the turning of a crank, which turns the shaft and pump rotor. The pump is designed to supply oil to the bearings during normal startup and shutdown of the auxiliary turbine in place of a motor driven auxiliary lube oil pump or to serve as a backup device. For specific information concerning the hand-operated auxiliary lube oil pump operation, consult the applicable EOSS procedure or equipment technical manual.

502-4.2 BEARINGS: GENERAL INFORMATION

502-4.2.1 GENERAL. The term bearing is used to refer to an object which supports a moving element in a machine. The function of a bearing in auxiliary turbines is to keep the shaft or rotor aligned correctly with the stationary parts when acted upon by radial or axial loads. The bearing that holds the shaft/rotor in the correct radial position and absorbs radial forces is called a **journal (line) bearing.** The bearing that holds the turbine shaft/rotor in the correct axial position and absorbs axial forces is called a thrust bearing. In many applications, the **thrust bearing** and journal bearing are combined. This section contains only general information concerning bearings. For detail bearing information including bearing type, intended service, material, installation, inspection, clearances, or maintenance, refer to **NSTM Chapter 244, Propulsion Bearings and Seals,** the applicable equipment technical manual, or **NSTM Chapter 231, Propulsion and SSTG Steam Turbines.**

502-4.2.2 JOURNAL BEARING. Most of the journal bearings used in auxiliary turbines are of the babbitt-lined, split sleeve type. Babbitt is a soft lead or tin based metal deposited on the inside diameter of the bearing shell. The babbitt absorbs contact without damage to the shaft/rotor. Journal bearings are designed to carry the weight of the rotor and maintain the correct radial clearances between the rotor and casing. The bearings will also support dynamic loads from mechanical rotor unbalance and coupling forces. The bearing operates on the hydrodynamic film principle and must have sufficient oil flow to operate properly. The equipment technical manual detail drawings on Maintenance Requirement Cards (MRC's) specify the design oil clearances for turbine bearings. If the clearances become greater than the allowable stated in the equipment technical manual, the bearing shall be rebabbitted or replaced. On high speed auxiliary turbines utilizing thin shell bearings, the babbitt thickness is 3.175 mm (1/8 inch) or less. The thin layer of babbitt metal permits a higher rate of heat dissipation than occurs in conventional type bearings. Thin shell bearings should not be rebabbitted. When clearances become excessive, the bearings must be replaced.

502-4.2.3 THRUST BEARINGS. Thrust bearings are used on auxiliary turbines to maintain the turbine rotor in the correct axial position relative to the stationary parts, and to absorb axial forces. Three types of thrust bearings utilized in auxiliary turbines are as follows:

a. Pivoted segmental thrust

b. Nonsegmental or tapered land thrusts

c. Ball thrust

502-4.2.3.1 Pivoted Segmental Thrust Bearings. The thrust bearing most utilized on auxiliary turbines is the pivoted segmental type such as those manufactured by Kingbury or Waukesha. The bearing consists of several pivoted segments or shoes and a revolving thrust collar attached to the shaft. The shoes and collar are encased in a housing and are immersed in oil. As the shaft turns, the rotation of the thrust collar forces oil under one end of each of the shoes, causing the shoes to tilt and support the thrust load in a**sledding** type action. Increasing the speed will cause the shoe angles to increase, thus increasing the sledding action. The thrust load is equally distributed on each shoe due to the leveling plate located between the shoes and base ring. The base ring maintains the alignment of parts and transmits thrust loads to the bearing housing. The thrust collar is made of uniform thickness forged steel. Great care is taken to make the working surfaces flat, smooth, and at right angles with the shaft. The marks left by final machining or grinding are removed by lapping. The shoes are faced with babbitt and the bearing surfaces are machined and scraped to an accurate surface finish. If necessary end play may be adjusted, within reasonable limits, by changing the thickness of shims that are usually provided between the base ring or leveling plate and the thrust bearing end cover. For specific procedure, consult the applicable PMS or equipment technical manual.

502-4.2.3.2 Nonsegmental or Tapered Land Thrust Bearings. Nonsegmental type thrust bearings consist of a thrust collar fastened to the shaft, and two babbitt-faced thrust plates between which the collar rotates. On some turbines with nonsegmental thrust bearings, one end of a journal bearing is faced with babbitt and serves as a thrust plate. Other turbines have two collars secured on the shaft, one at each end of the journal bearing with each end of the journal bearing provided with a vertical babbitted face serving as a thrust plate. Some turbines use a nonsegmental thrust bearing called a **tapered land** thrust bearing. In this type of thrust bearing, the stationary surface on the side that absorbs the thrust is a solid ring with a babbitted surface. A series of about six radial grooves are cut in the babbitt for distribution of oil. Each babbitted surface between the radial oil groove is machined tapered in both circumferential and radial directions to provide a wedge shaped oil film. The inactive stationary thrust surface is not tapered. With proper lubrication, the lands of collar thrust bearings should experience little or no wear and the designed end play will change very little with service. Shims are generally provided between the thrust plates and their housing and, if necessary, end play can be adjusted, within reasonable limits, by changing the thickness of the shims. In some tapered land type bearings the entire bearing is arranged to pivot on a yoke and holding plate located at the end of the bearing assembly. When nonsegmental thrusts are dismantled for inspection, the grooves in the thrust plates for distribution of oil over the thrust surfaces should be carefully cleaned of all dirt and sediment to assure free flow of oil. For specific procedure, consult the applicable PMS or equipment technical manual.

502-4.2.3.3 Ball Thrust Bearings. Ball thrust bearings are used in auxiliary turbines that operate at a relatively slow speed. The bearings are built to carry a heavy load by pure rolling motion on an angular contact of either single or double row mounting. The axial load is equally distributed to all the balls around the race, resulting in a small fraction of the axial load being carried on each ball. It is essential that the balls be equally spaced, therefore, a retaining cage is used between the balls and between the outer and inner race. Clearance is provided between the periphery of the outer race and the housing to assure that no radial load will be taken. In some cases when the axial load is relatively small and space limitations require it, ball bearings are used to take both axial and radial loads. In cases where a ball bearing is provided for taking axial loads only, it will have a radial clearance. When inspecting ball thrust bearings, ensure that the outer races are secured axially. If the ball bearing is intended for radial loads, the outer races should be free to float axially in their housings in order to adjust themselves to linear expansion.

502-4.3 GOVERNORS

502-4.3.1 GENERAL. All auxiliary turbines in use throughout the Navy are equipped with governors of either the speed-limiting or speed-regulating type or both. Operating personnel should be familiar with the type of governor installed on each auxiliary turbine and ensure that it is set properly, tested, and maintained in operating condition. Because of the relative complexity of the hydraulic systems associated with governors, the applicable equipment technical manuals cover their operation and checkout in considerable detail. When governor settings are checked, two independent speed measuring devices should be used. One of the speed measuring devices should be a nonstroboscopic tachometer such as a hand held mechanical tachometer. For information concerning tachometers refer to **NSTM Chapter 491, Electrical Measuring and Test Instruments, or NSTM Chapter 504, Pressure, Temperature, and Other Mechanical and Electromechanical Measuring Instruments.**

502-4.3.2 SPEED-LIMITING GOVERNORS. A speed-limiting governor is fundamentally a safety device for variable speed turbines. The speed-limiting governor will allow the turbine to operate under normal operating conditions but will not permit the turbine to operate at any speeds that exceed the governor setting regardless of turbine load. The speed-limiting governor has no control of the steam admitted to the turbine until the set governor speed is reached, regardless of load, exhaust pressure, or other conditions. Speed-limiting governors are either the centrifugal type or the hydraulic type. For turbine driven centrifugal pumps (not propeller type) the no-load condition, in regard to speed regulation, is considered as the lowest load attainable with the pump operated at shut-off condition; i.e., with the discharge valve closed. Under any condition of operation, including loss of pump suction, the speed-limiting governor shall limit the speed of the turbine to approximately rated speed.

Speed-limiting governors must be provided on all auxiliary turbines. The speed-limiting governor must be kept operative at all times and must never be lashed down. Refer to the PMS procedures or applicable equipment technical manuals for proper maintenance, testing requirements, and speed-limiting governor settings.

502-4.3.2.1 Centrifugal Type Governor. The centrifugal type governor usually contains two flyweights pivoted to a yoke on the governor shaft and carry arms which bear on a push rod assembly. The push rod assembly is held down by a strong spring. As a result of centrifugal force, the position of the flyweights is a function of turbine speed. As the turbine speed increases and approaches the set governor speed, the flyweights move outward and lift against the spring tension. As the speed begins to exceed the governor setting, the flyweights move farther out, causing the governor valve to throttle down on the steam, thus limiting the turbine speed. As the turbine slows down, the centrifugal force on the flyweight is decreased and the governor push rod spring pulls the flyweights in. This allows more steam to be admitted to the turbine until a normal operating speed is obtained.

502-4.3.2.2 Hydraulic Type Governor. The hydraulic type governor senses speed as a function of oil flow from the positive displacement attached lube oil pump and regulates the turbine at a predetermined flow rate.

502-4.3.3 SPEED-REGULATING GOVERNORS. A speed-regulating governor controls and regulates the flow of steam to the turbine, changing the speed and thereby changing the flow from the driven equipment as required by an external signal. Most turbine driven pump governors maintain a constant pressure at the pump discharge. Changes in this pressure signal result in the governor changing the position of the governor valve and steam flow through it, thereby changing the pump and turbine speed to return the pump discharge pressure to the set pressure. Speed-regulating governors for forced draft blowers regulate the governor valve in the same way to match air flow to boiler demand. Speed-regulating governors may be of the hydraulic, mechanical, or centrifugal type. Refer to the applicable technical manual for detailed construction and operation.

502-4.3.4 OTHER TURBINE CONTROL DEVICES. Other turbine control devices that may be encountered in the Fleet include hydraulic, pneumatic, or electric controls for main feed pumps. On ships with automatic combustion controls, the main feed pump controls will usually be tied in to the boiler controls. Regardless of the type governor on the auxiliary turbine, the control oil must be kept clean and free from foreign particles. The governors must be kept in operational condition at all times. The governors should be maintained and tested in accordance with equipment technical manuals and PMS procedures.

502-4.4 OVERSPEED TRIPS

502-4.4.1 To ensure that auxiliary turbines will not operate at speeds greater than that for which they are designed, some turbines are fitted with overspeed trips. The overspeed trip mechanisms vary in design depending on the manufacturer. All overspeed trip mechanisms consist of the following:

a. Speed-sensing device senses turbine speed and sends a signal to the relay medium. It can be centrifugal, magnetic proximity pick-up, or permanent magnetic generator.

b. Relay medium compares turbine speed with a predetermined setting and causes the trip valve to close when this setting is exceeded. It can be mechanical, hydraulic, electrical, or a combination of the three.

c. Trip valve shuts off all steam flow to the turbines.

502-4.4.2 For specific information concerning the overspeed trip mechanism trip speed, design operation, or maintenance, refer to the applicable EOSS procedures, PMS procedures, or equipment technical manuals.

NOTE

Overspeed trips shall NEVER be lashed down nor otherwise rendered inoperative.

502-4.5 ELECTRONIC OVERSPEED PROTECTION SYSTEM FOR MAIN FEED PUMPS

502-4.5.1 The electronic overspeed protection system is designed to provide positive turbine shutdown in the event that an overspeed condition occurs. Refer to the applicable EOSS procedures, PMS procedures, or equipment technical manuals for the predetermined trip speed. In addition, this system provides a safe method for testing all the overspeed circuitry and trip valve at one-half the normal trip speed to verify that the turbine will actually shut down when required.

502-4.5.2 The system basically consists of the following components:

a. Magnetic Pickup/Toothed Rotor Assembly - A gear mounted on the turbine shaft provides a speed-sensing point. As the teeth on the gear pass the tip of the magnetic pickup, a speed signal is sent to the main control unit.

b. Main Control Unit - This remotely mounted unit monitors turbine speed via magnetic pickup/toothed rotor assembly. It will energize the trip valve solenoid when the set trip speed is achieved. In addition, it has capabilities for testing the system at one-half the actual turbine trip speed as well as system fault detection.

c. Overspeed Trip Valve - This valve is positioned at the steam inlet line to the turbine and can be tripped closed to stop the turbine when energized by the main control unit.

d. Remote Indication Unit - This unit provides operators with the turbine trip status.

502-4.6 GLAND PACKING

502-4.6.1 GENERAL. Packing is fitted around the shafts of all turbines to prevent the leakage of steam from the turbine casing. The shaft packing must be sealed properly to obtain efficient turbine operation. Carbon rings and labyrinth type rings are the two types of shaft packing used in auxiliary turbines (see Figure 502-4-3, Figure 502-4-4, and Figure 502-4-5).

502-4.6.2 CARBON RINGS. Carbon ring packings consist of four or five rings which are positioned around the turbine shaft on both sides of the turbine wheel. Each ring is divided into three or four segments and held together by a spring. Each ring is held loosely in a housing so that the ring will float around the shaft preventing hard contact between the carbon ring and the shaft. Steam pressure from the turbine exhaust seats each ring against the housing preventing steam from leaking around the packing. A small amount of steam is allowed to leak through the small clearance between the rings and the shaft.

502-4.6.3 LABYRINTH RINGS. Labyrinth rings consist of two rings which fit around the shaft on both sides of the turbine wheel. Each ring is divided into four segments and held together by springs. Each ring is held loosely in a housing so that the ring will float around the shaft preventing hard contact between the ring and shaft. Exhaust steam pressure seats each ring against the housing to prevent steam leakage around the packing. The inside diameter of each labyrinth ring has several knife edges which extend close to the shaft to minimize leakage area. The space between the two rings is connected to the gland exhaust system which creates a vacuum at this point. The inner ring (steam labyrinth) restricts steam leakage down the shaft. Similarly, the outer ring (air labyrinth) restricts leakage of air down the shaft. The gland exhaust system carries all steam and air leakage away from the turbine.

502-4.7 AUXILIARY GLAND EXHAUST LEAK-OFF SYSTEM

502-4.7.1 Main feed pumps and forced draft blowers with labyrinth ring packing are serviced by the auxiliary gland exhaust leak-off system. This system carries steam and air leakage away from the turbine gland to a condenser where the steam is condensed. This system operates under a vacuum of 10 to 15 inches of water.

502-4.8 LOOP SEAL DRAINS

502-4.8.1 The auxiliary gland exhaust system piping for noncondensing turbines must be installed with a continuous downward slope from the glands to the header, wherever possible. If low points or pockets exist in the piping, loop seal drains must be installed as stated in NAVSEA S9AAO-AA-SPN-010, **General Specifications for Ships of the United States Navy,** Section 253F. The loop seal drain will allow condensate which forms in the lines to drain without affecting vacuum. The loop seal drain cannot be hard piped. It must drain into a funnel leading to the bilge.

502-4.8.2 A critical loop seal drain diagram is shown in Figure 502-4-6. The dimension A (in inches), should be equal to or greater than one-half of the vacuum in inches of water being maintained by the gland exhaust system. The loop seal drain must be filled with (2A) inches of water prior to light-off to ensure proper loop seal drain operation. This can be accomplished by removing the fill cap and pouring water into the fill connection until the water level rises to the top of the fill connection, then replace fill cap. On initial light-off of the gland exhaust system the (2A) inches of water in the loop EE-DD-CC is pulled into leg CC and half of BB. As condensate forms in the loop seal, the water level in EE and BB-CC rises equally until EE is completely filled. At this point any additional water added to the loop seal is drained off through FF and the funnel. Therefore, it is critical that leg BB-CC be a minimum of (2A+A) inches long. This will ensure proper loop seal drain operation. Consult the applicable system design drawings or equipment technical manuals for loop seal drain dimensions and pipe sizes.

502-4.9 EXHAUST CASING PROTECTION AGAINST EXCESSIVE PRESSURE

502-4.9.1 In order to protect turbine exhaust casings against excessive pressures, a number of different devices are fitted on different turbines. These protective devices include combined exhaust and relief valves, full relief valves, spring-loaded exhaust valves, and sentinel valves.

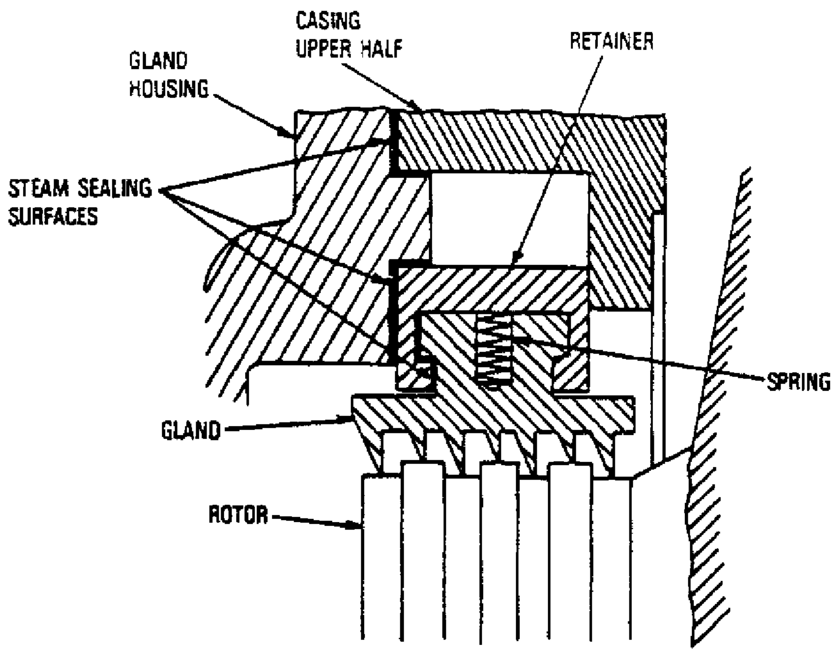

Figure 502-4-3 Labyrinth Arrangement

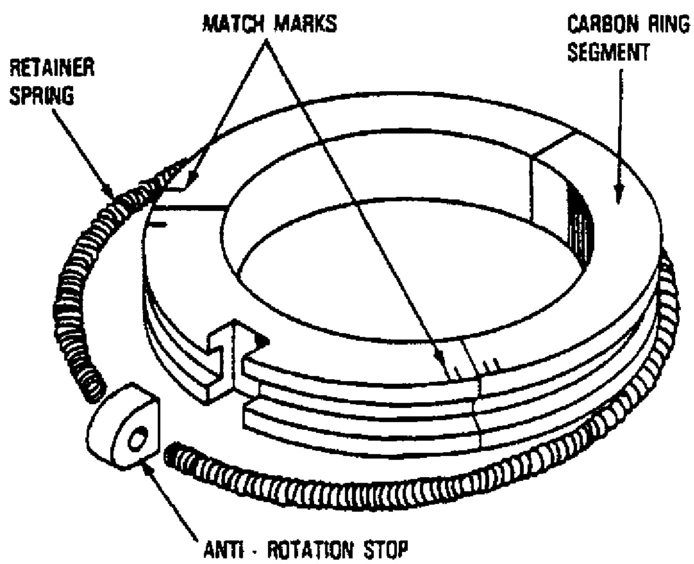

Figure 502-4-4 Carbon Ring Assembly

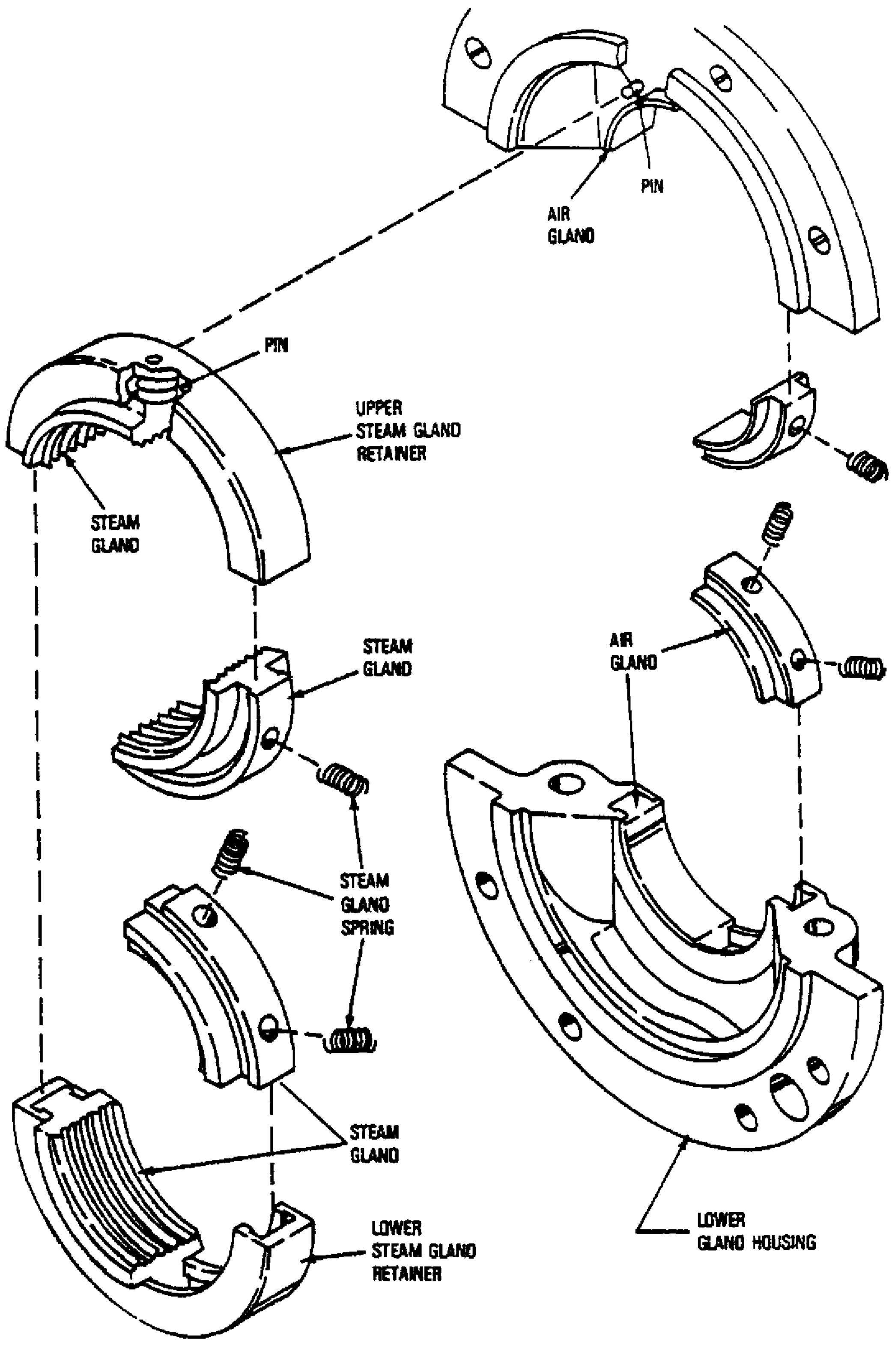

Figure 502-4-5 Steam and Air Glands

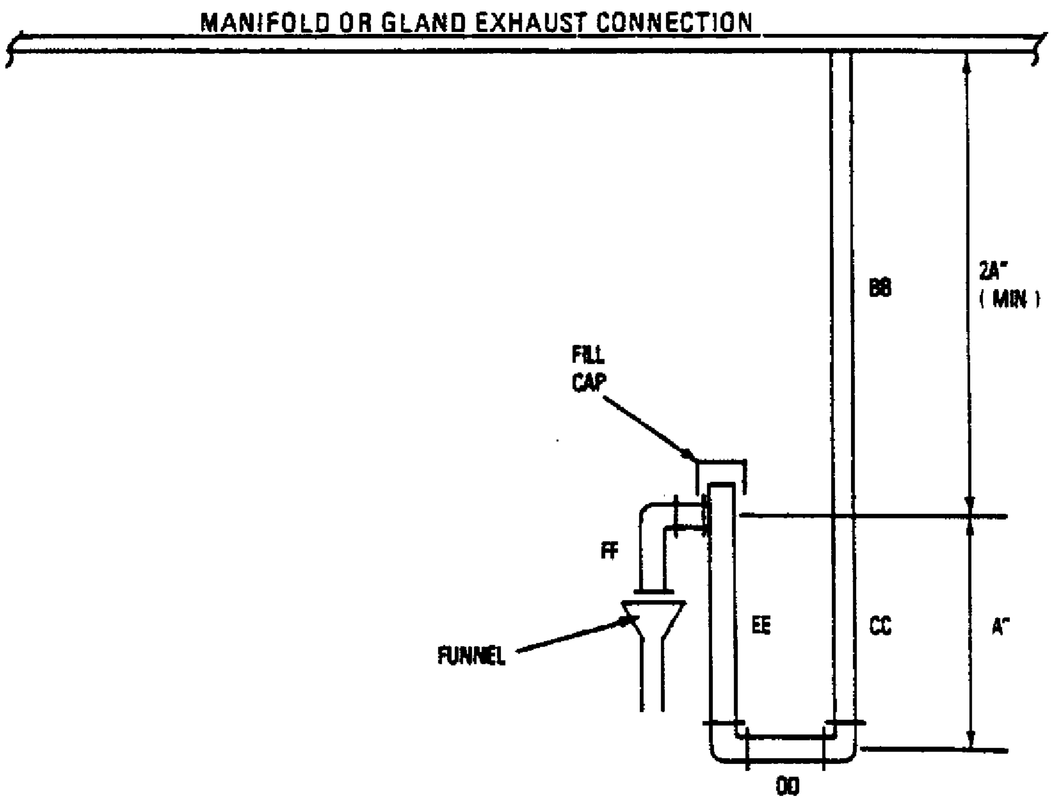

Figure 502-4-6 Loop Seal Drain Diagram

a. A combined **exhaust and relief valve** features a spring-loaded valve which opens when the turbine exhaust pressure exceeds the exhaust system pressure. This valve also acts as a check valve to prevent backflow of steam from the exhaust system into the turbine and can be manually locked when performing turbine maintenance.

b. **Full relief valves** are sized to provide venting to atmosphere of the full quantity of steam passing through the turbine. In the case of small turbine drives, the discharge may be piped to the bilge.

c. **Spring-loaded exhaust valves** may be supplied on some older turbines. These are devices which act as check valves between the common exhaust header and the turbine.

d. **Sentinel valves** are actually small relief valves which are installed to provide an audible signal to the operator that the turbine casing steam pressure is too high.

502-4.9.2 For noncondensing turbines provided with casing relief valves, the valve should be set from 2 to 5 lb/in^2 above the setting of the auxiliary exhaust atmospheric relief valve. Spring-loaded exhaust valves and combined exhaust and relief valves installed with noncondensing turbines should be set to lift at 2 lb/in^2 above the normal designed auxiliary exhaust line pressure.

502-4.9.3 Turbine sentinel valves used to warn of an undue increase in back pressure are not designed to relieve the turbine completely of excessive pressures. When a sentinel valve pops, the cause of the increase in pressure must be immediately determined. If necessary, shut down the turbine. Relief valves are sometimes provided with a threaded or flanged outlet to permit piping away the steam if the valve opens. The piping leading away from this valve shall not be plugged, nor shall any valve be installed in this line.

502-4.10 STEAM STRAINERS

502-4.10.1 Steam strainers are located in the steam line ahead of the governor valve to prevent foreign material from entering the turbine. The strainer is in the form of a basket made of wire mesh or perforated corrosion-resisting steel. The steam strainer should be examined and cleaned according to PMS procedures or more frequently if extensive cruising has been done or if dirt or scale has been found in the last cleaning. Some strainers are equipped with a blow-off connection for cleaning purposes. For specific steam strainer information, refer to the applicable PMS procedures or equipment technical manuals.

502-4.11 LOW OIL PRESSURE ALARMS AND TRIPS

502-4.11.1 Low oil pressure alarms and trips are provided on some auxiliary turbines. The alarms sound when the lube oil pressure drops to the minimum pressure recommended for safe operating conditions. The low oil pressure trip normally works in conjunction with the speed-limiting governor to shut down the turbine if the lube oil pressure drops below a predetermined minimum. The applicable equipment technical manual or PMS procedures should be consulted for the correct setting of low oil pressure alarms or low oil pressure trips. Where both protective devices are installed, the alarm is set 2 or 3 lb/in^2 above the trip setting. When a low oil pressure alarm sounds, the trouble should be identified and corrected immediately.

502-4.12 REDUCTION GEARS

502-4.12.1 Reduction gears are sometimes used with auxiliary steam turbines to drive pumps at slow speed. It is essential that the gear alignment and backlash be set properly and that sufficient oil be provided to ensure proper gear operation. For specific information concerning reduction gear applications, operation, assembly, alignment procedures, alignment requirements, maintenance, or repair, refer to the applicable PMS procedures, Technical Repair Standard (TRS), or equipment technical manuals.

502-4.13 COUPLINGS

502-4.13.1 For information concerning the various types of couplings used to connect auxiliary turbine shafts to the driven unit shafts, consult the following applicable documentation:

a. Equipment technical manual

b. PMS procedures

c. **NSTM Chapter 503, Pumps**

502-4.14 ALIGNMENT OF TURBINE WITH DRIVEN UNIT

502-4.14.1 The most important alignment in a horizontal turbine relates to the coupling between the turbine and the driven apparatus. The shafts of the two must be aligned correctly. Therefore, it is very important to determine that the faces and sides of the coupling run parallel and true to each other. The preliminary alignment is usually made when the apparatus is cold and before piping is connected. It should be kept in mind that the turbine center line may or may not rise as the turbine warms. The final alignment should be made after the turbine is connected to the piping. Alignment readings should be according to the equipment technical manual. Misalignment may result in excessive vibration, causing the bearings to wear rapidly.

NOTE

Consult the applicable PMS procedure or equipment technical manual for detailed instructions concerning alignment procedures and specifications including cold and hot alignment check requirements.

502-4.15 GOVERNOR VALVES

502-4.15.1 Governor valves are controlled by the speed-regulating governor or the speed-limiting governor or both. Proper governor valve operation is critical to proper turbine operation. Governor valves consist of a housing which contains one or more valve plugs and seats with bushings and packing to properly align the plug and seat and prevent steam leakage while the valve controls steam flow to the turbine. The valve plug/stems should be straight and free to move in the stem bushings/packing. Packing (where used) should be tightened to prevent both stem binding and steam leakage. The valve seats should be secured in the valve body (normally seal welded). The seating area of both the seats and the plugs must be properly hard faced and free of steam cuts. For information concerning governor valve design, inspection, and maintenance, refer to the applicable PMS procedures, equipment technical manual, or TRS.

SECTION 5.

TROUBLESHOOTING

502-5.1 INTRODUCTION

502-5.1.1 The purpose of this section is to provide guidance regarding the possible sources of problems based on observed symptoms. General troubleshooting information for auxiliary steam turbines is provided in Table 502-5-1 and should be used in conjunction with the troubleshooting sections of the applicable equipment technical manuals.

502-5.1.2 When troubleshooting to determine the cause of a particular symptom or problem, check the least difficult and most likely component first, proceeding in steps to the least likely and most difficult, until the causes of the problem are identified and corrected.

NOTE

Table 502-5-1 is similar to the troubleshooting sections found in most auxiliary steam turbine technical manuals. The information in this table is general information and is similar for all auxiliary turbines. For specific troubleshooting information concerning a particular auxiliary steam turbine (and driven auxiliary), consult the applicable equipment technical manual.

Table 502-5-1 GENERAL TROUBLESHOOTING PROCEDURES

Problem	Possible Cause	Recommended Action
Turbine Fails to Start	a. Proper Engineering Operational Sequencing System (EOSS) not followed	Follow prescribed EOSS procedures. Refer also to paragraph 502-3.2.
	b. No lubricating oil pressure	The lube oil system must be pressurized by operating the motor driven or hand operated lube oil pump before the turbine can be started.
	c. Improper adjustment of low lube oil trip mechanism	Adjust low lube oil trip mechanism.
	d. Rotor and shaft assembly binding (will not turn by hand)	Disassemble, inspect, and repair in accordance with the equipment technical manuals.
Low Lubricating Oil Pressure	a. Clogged oil filter	Clean oil filter. (Refer to paragraph 502-4.1.2)
	b. Low oil in the reservoir	Fill reservoir with lube oil.
	c. Broken lube oil lines	Repair broken lines.
	d. Improper adjustment of oil regulating valve	Adjust oil regulating valve.
	e. Worn or damaged attached lube oil pump internals	Disassemble, inspect, and repair attached lube oil pump. (Refer to paragraph 502-4.1.6)
	f. Obstruction in lube oil lines	Remove obstruction from lines.
High Oil Temperature To Bearings	a. Insufficient cooling water flow through cooler	Ensure auxiliary cooling water system is operating according to EOSS procedures.
	b. Oil cooler bypass valve not fully in Cooler position	Turn the oil bypass valve fully to the Cooler position.
	c. Clogged or plugged tubes on water side of oil cooler	Disassemble and inspect oil cooler according to the technical manual.
	d. Excessive sludge deposits on oil side of oil cooler	Disassemble and clean oil cooler.
High Oil Temperature From Bearings (i.e., temperature rise across bearing is in excess of 27.8° C (50° F) or oil discharge temperature in excess of 82.2° C (180° F)	a. Clogged lube oil orifice to bearings b. Dirt within the bearing c. Improper clearance or fittings of bearings d. Excessive steam blowing from turbine steam glands heating bearings or oil drain line	Disassemble, inspect, and clean orifice. Disassemble, inspect, and clean bearings. Disassemble and inspect bearings for proper contact and installation. Check the operation of auxiliary gland exhaust leak-off system in accordance with EC procedures. (Refer to paragraph 502-4.7) Disassemble and inspect turbine steam gland seals.
	e. Wiped or excessively worn bearing	Inspect bearings. (Refer to paragraph 502-6.4)
	f. Oil from oil cooler in excess of 54.4° C (130° F)	Inspect lube oil cooler.
	g. Clogged drain lines from bearings	Disassemble, inspect, and clean bearing oil drain lines.
Low Oil Temperature to Bearings (Less than 48.9° C (120° F))	a. Excessive cooling water flow through lubricating oil filter	Decrease cooling water flow through cooler. Allow oil to bypass cooler. Check cooling water orifice for proper size and location.

Table 502-5-1 GENERAL TROUBLESHOOTING PROCEDURES - Continued

Problem	Possible Cause	Recommended Action
Lube Oil Contaminated With Water (determine by chemical analysis whether fresh or salt water)	a. Leakage resulting in salt water in lube oil b. Leakage resulting in fresh water in lube oil c. Centrifugal separator not operating properly d. Excessive steam seal leakage e. Steam valve leaking	Disassemble and repair lube oil cooler. Purify oil according to EOSS procedures. Inspect and repair centrifugal separator, if provided. (Refer to paragraph 502-4.1.4) Refer to gland seal leakage troubleshooting procedures or paragraph 502-4.6, 502-4.7, or 502-4.10. Inspect and repair steam valve according to the equipment technical manual.
	Note Leave the low pressure drains open when the unit is secured.	
Steam Blowing From Turbine Glands	a. Improper operation or alignment of auxiliary gland exhaust system	Check operation of gland exhaust system according to EOSS procedures. (Refer to paragraph 502-4.6 or 502-4.7)
	b. Worn steam/air glands or improper seating of gland steam sealing surfaces	Disassemble, inspect, and repair steam and air glands.
	c. Improperly installed gland seals or housing	Check that seal segments and housing are properly installed.
	d. Top half of seal housing not concentric with lower half	Check for matchmarked set of seal housings. Check labyrinth housings and turbine casing for proper alignment of upper half to lower half. Ensure that all dowels are installed and fully inserted.
	e. Excessive auxiliary exhaust pressure (in excess of 20 lb/in^2 g)	Ensure that auxiliary exhaust system is lined up according to EOSS procedures.
Maximum Turbine Operating Speed Is Too High	a. Speed-limiting governor set too high	Adjust speed-limiting governor. (Refer to paragraph 502-4.3.2)
Maximum Turbine Operating Speed Is Too Low	a. Low steam pressure or partially closed root steam valve b. Speed-limiting governor set too low c. Sticking governor valve stem d. Clogged steam strainer	Check root steam valve for fully open position. Adjust speed-limiting governor. (Refer to paragraph 502-4.3.2) Disassemble, inspect, and adjust. Disassemble, inspect, and clean. (Refer to paragraph 502-4.10)
Overspeed Trip Does Not Function Properly	a. Improper adjustment of overspeed trip monitor b. Failure of overspeed trip components	Adjust setting of overspeed trip monitor. Replace/repair overspeed trip components. (Refer to paragraphs 502-4.4 and 502-6.6)
Governor Valve Apparently Closes but Turbine Speed Fails to Drop Below Approx. 200 RPM (depending on type of unit)	a. Improper seating of governor valve b. Governor valve seat is cut	Check and adjust governor valve seating. Disassemble, inspect, and repair according to technical manuals. (Refer to paragraph 502-4.1.5)

Table 502-5-1 GENERAL TROUBLESHOOTING PROCEDURES - Continued

Problem	Possible Cause	Recommended Action
Excessive Turbine Vibration	a. Wiped or worn bearing	Disassemble, inspect, and repair bearings. (502-6.4)
	b. Excessive thrust clearance, causing possible rubbing of internal parts	Check condition of thrust bearing and adjust thrust clearance. (Refer to paragraph 502-6.5)
	c. Rotor not balanced	Inspect, repair, and balance rotor.

SECTION 6.

INSPECTIONS AND MAINTENANCE PROCEDURES

502-6.1 GENERAL INFORMATION

502-6.1.1 This section contains general inspection and maintenance procedures for auxiliary turbines. Due to the great variation of auxiliary turbines on Navy ships, specific information concerning inspections, maintenance, and repair can be found in the following documentation.

a. Equipment technical manual

b. Planned Maintenance System (PMS) requirements

c. Equipment Technical Repair Standard (TRS)

502-6.1.2 The PMS procedures must be followed exactly to ensure that the auxiliary turbines are properly maintained.

502-6.2 GENERAL CARE AND INSPECTION

502-6.2.1 The turbine should be inspected and have routine maintenance performed according to PMS procedures. The following steps provide general inspection and maintenance points and actions should be accomplished according to PMS procedures:

1. Inspect the turbine foundation and the unit itself for loose or broken nuts and bolts. If any is found, it shall be tightened or replaced immediately.
2. The turbine casing should be inspected, especially near glands and in all locations where water may collect in pockets or under the lagging. Experience has shown that where water or dampness is permitted to remain in contact with the casings, the casings may be seriously weakened by corrosion before the situation is discovered. Where drain holes are provided in pockets, these holes must be kept open when the turbine is secure, and they should be of such size that they are not easily stopped up. Where indications of active corrosion are discovered, the affected surfaces should be properly bared and cleaned to good metal, removing lagging where required to accomplish this. The exposed surface should then be dried and painted with two coats of an approved paint. Lagging should then be replaced and such steps as may be practical taken to prevent recurrence.
3. All sliding contacts and pivot points in the governor and overspeed tripping mechanisms shall be kept free,

clean, and well oiled in order that there will be no sticking which might prevent the safety devices from functioning at the rotational set speed. Particular attention shall be given to the condition of split pins or other securing devices on overspeed tripping mechanisms.

4. When a turbine is new, or after extensive repairs have been made to a unit, renew or renovate the oil in the reservoir frequently. At other times renew the oil or run it through the purifier often enough to ensure that it is perfectly clean. When considered necessary, flush out the system by running the turbine slowly for several minutes with an approved flushing oil in the system in order to thoroughly clean out all lines, bearings, and pockets. Then drain off the flushing compound and fill the reservoir with clean oil.

502-6.3 ACCUMULATION OF DEFECTS

502-6.3.1 Defects such as pitting of ball races, excessive clearance in bearings, excessive clearance between steam nozzles and rotors, misalignment, dirt clogged oil system and oil regulating valve, leaky valves, excessive wear in oil pumps, and leaky packing and related defects should not be allowed to accumulate. Such accumulation is preventable by performing the required PMS and utilizing the Engineering Operational Sequencing System (EOSS) procedures when operating auxiliary turbines.

502-6.4 BEARING WEAR

502-6.4.1 Auxiliary turbine bearing wear must be inspected according to PMS procedures. Calibrated instruments such as feeler gauges and micrometers should be used for inspection purposes. Excessive bearing wear can be avoided if the bearings are installed and aligned properly and if the correct lube oil pressures and temperatures (refer to paragraph 502-3.2.1, step 13) are maintained. Vibration problems or high lube oil temperatures from the bearings can indicate excessive bearing wear or misalignment. For specific information concerning bearing installation, alignment, inspection procedures, wear limits, clearances, or maintenance requirements, refer to the applicable PMS procedures, equipment technical manuals, or **NSTM Chapter 244, Propulsion Bearings and Seals** .

502-6.5 THRUST BEARING END PLAY

502-6.5.1 The allowable end play for turbine thrust bearings can be found in the applicable technical manual, PMS requirements, or manufacturer design drawings. In general, the easiest way to check the end play of auxiliary turbines is by moving the rotor to one extreme axial position thrust then to the other with the thrust shoes in place, measuring the travel using a dial indicator. The normal operating end play of auxiliary turbine thrust bearings is approximately 0.203 mm (0.008 inch) to 0.036 mm (0.014 inch). On turbines driving through helical gears, the rotors may be shifted to extreme axial positions by merely turning the shaft in one direction and then in the other direction. For specific details of checking the end play on various auxiliary turbines, consult the applicable equipment technical manual or PMS procedures.

502-6.6 TEST OF OVERSPEED TRIPS AND SPEED-LIMITING GOVERNORS

502-6.6.1 Overspeed trips and speed-limiting governors should be tested according to applicable EOSS procedures, PMS procedures, or equipment technical manuals.

502-6.6.2 Overspeed trips are installed primarily for the protection of operating personnel and great care must be exercised in their testing and maintenance. The mechanical overspeed trip must be tripped by hand to ensure that the mechanism operates properly. If an electronic overspeed trip device is provided, it must be tripped/actuated at a predetermined reduced operating speed to ensure that the system functions correctly.

NOTE

The overspeed trips shall be tested according to PMS requirements and procedures.

502-6.6.3 For information concerning the overspeed trip design, test procedures, trip settings, or maintenance requirements, refer to the applicable PMS procedures, EOSS procedures, or equipment technical manuals.

502-6.6.4 The speed-limiting governor (refer to paragraph 502-4.3.2) must be tested according to PMS requirements. The same tachometer requirements as stated in paragraph 502-4.3.1 should be observed when performing the speed-limiting governor test.

CAUTION

It is NOT permitted to test the speed-limiting governor with the turbine uncoupled, the relief valves gagged open, or against a steaming boiler unless specifically permitted in the applicable PMS.

If the speed-limiting governor cannot be tested according to PMS procedures, notify the Naval Sea Systems Command or Naval Ship Systems Engineering Station.

502-6.7 ROTOR CLEARANCES

502-6.7.1 Axial flow turbines are generally provided with an opening in the casing for the purpose of inspecting the blade clearances. Tapered gauges are inserted between the nozzle face and shroud land of the first row of blades for the measurement of axial clearance. If the clearance is found to be outside the limits specified by the equipment technical manual, the position of the rotor should be adjusted accordingly. After adjusting the clearance, rotate the rotor by hand to ensure that there is no rubbing.

502-6.7.2 Helical flow turbines such as those having integral buckets must always be kept in axial alignment with the nozzles and reversing chambers. If this is not done, the steam will spill over the edges of the wheel and reversing chambers, resulting in reduced economy and power.

502-6.7.3 For specific information concerning rotor design, clearances, or alignment or adjustment procedures, refer to the applicable PMS procedures or equipment technical manuals.

502-6.8 VIBRATION

502-6.8.1 Vibration in a turbine indicates that the unit is not operating properly. When excessive or unusual vibration is noted in a turbine, the problem should be investigated immediately, the cause determined, and the problem corrected. If the problem is not remedied, it is possible that (a) the bearing and packing/gland clearances will become excessive causing oil and steam leakage or, (b) the turbine will become completely inoperable. If a vibration problem is suspected, trained personnel should be called in to take vibration/noise level readings.

502-6.8.2 Vibration of a turbine may be caused by:

a. Worn journal bearings

b. Worn thrust bearings

c. Parts rubbing or binding

d. Driven unit out of balance

e. Driven unit out of alignment

f. Turbine rotor out of balance

g. Loose or broken foundation bolts

h. Improper steam and air gland clearances

i. Improper carbon packing clearances

j. Bent shaft

502-6.8.3 To correct these problems, refer to the applicable PMS procedures, equipment technical manual, or equipment TRS.

502-6.9 CARE OF BABBITTED BEARING SURFACES

502-6.9.1 If the babbitted surfaces of thrust or journal bearings become bruised, the bruises should be removed by scraping the surfaces with a special scraping tool. Care must be taken when scraping bearings, and only trained personnel should attempt this task. Babbitted bearing surfaces can be scraped for the following reasons:

a. To dress off rough edges left by machinery and to blend oil distribution pockets into bearing bores

b. To improve contact pattern

c. To remove high spots

d. To clean up a slight wipe or to remove imbedded foreign particles.

502-6.9.2 Slight rusting of thrust collar faces may be removed with a fine oil stone. If deep rusting occurs, refinishing of the collar faces will be required. Never use a coarse-grained stone, a scraper, or file on the collar faces.

502-6.10 EXCESSIVE STEAM LEAKAGE

502-6.10.1 Excessive steam leakage from the turbine gland area can be caused by a faulty auxiliary gland exhaust leak-off system or worn packing. The gland exhaust system should be inspected prior to the packing, to determine if proper vacuum (approximately 10 to 15 inches of water) is being maintained (refer to paragraph 502-4.7). The gland exhaust system should be inspected, tested, and maintained according to applicable PMS procedures or the equipment technical manuals. If the gland exhaust system is not at fault, steam leakage at the packing glands may be due to worn packing or to leakage between the packing and the packing housing. Close attention must be paid not only to sealing steam leakage along the shaft, but also to any leakage paths between the packing and packing retainer and the packing retainer and the packing housing.

502-6.10.2 Labyrinth segments (see Figure 502-4-3 and Figure 502-4-5) must be installed and aligned correctly to avoid contact between the labyrinth and shaft. The labyrinth must have perfect knife edges and the grooves must be clean and free from foreign matter. For information concerning labyrinth seal design, operation, clearances, or maintenance requirements, refer to the applicable PMS procedures or equipment technical manuals.

502-6.10.3 Carbon packing rings in good condition show a uniform glazed surface on the inside diameter. Scoring observed on the shaft should be carefully smoothed, taking care to reduce the shaft diameter as little as possible. Carbon packing rings are designed to operate without lubrication and do not require any other than the natural lubricant contained in them. The presence of even the smallest amount of grease or oil in any form will prevent them from operating properly. Should the sealing surfaces of a packing housing become scratched or damaged, they should be restored by the use of a very smooth oil stone moistened with kerosene. When carbon packing is disassembled for inspection or renewal, special care must be taken to ensure that the rings are installed in the proper grooves. Each segment is generally marked with the groove number in which it is assembled; usually the groove numbers are also stamped on the gland case.

502-6.11 FITTING CARBON PACKING RINGS

502-6.11.1 GENERAL. The following paragraphs refer to fitting of carbon packing rings in general terms. For specific information and instruction on fitting carbon packing rings, refer to the applicable equipment technical manuals or TRS'S.

502-6.11.2 CARBON RING JIG (FOR RINGS WITH CLEARANCE). Accurately fitting the joints and bores of carbon packing on turbine shafts is a difficult job that must be accomplished by hand after the original installation. A carbon ring jig and gauge (see Figure 502-6-1) as described herein may be used to fit carbon rings in order to simplify such fitting and reduce the time required. One size of each jig and gauge is required for each bore of carbon rings. The jig can be made by using a square steel plate of a size approximately 38 mm (1-1/2 inches) greater than the inside diameter of the carbon ring. The thickness should be approximately 9.5 mm (3/8 inch) greater than the width of the ring to be fitted. The upper part of the steel plate should be turned to a diameter of 0.025 mm to 0.051 mm (0.001 inch to 0.002 inch) less than the final bore required for the carbon ring. The width of the turned surface should be about 3.18 mm (1/8 inch) greater than the width of the carbon ring. The periphery of the turned surface should have marks scribed in a diagonal direction, approximately 12.7 mm (1/2 inch) pitch and deep enough to raise a cutting edge. A depth of 0.076 mm (0.003 inch) is considered sufficient. At the bottom of this turned surface, add a 1.59 mm (1/16 inch) radius undercut in the adjacent surface to permit the corner of the carbon ring to bear properly on the turned surface. One side of this slot must pass through the dead center of the turned surface and be true with it. Stamp an X on the upper face adjacent to the side of the slot through the dead center, and at each end of the slot remove all sharp edges from the slot and edge of the turned surface. Add two countersunk holes for wood screws in the portion of steel plate which remains square for securing fitting jig to a board. The heads of the wood screws should seat at least 0.794 mm (1/32 inch) below the surface.

502-6.11.3 CHECKING GAUGE. The checking gauge can be made by turning a piece of steel to the same diameter as the shaft for which the carbon ring is to be used. The thickness should be 3.18 mm (1/8 inch) greater than the width of the ring. Drill and countersink for a wood screw through center. Both jig and gauge can be fastened to a suitable board for convenience in handling and stowage and both parts may be lightened if desired by adding a bore through the center.

502-6.11.4 METHOD OF FITTING. Assemble the carbon ring with its garter spring. Place it on the gauge and check the fit of the joints and the clearance between gauge and ring with feelers. If the joints fit properly, or if the bore is too large, remove the ring from the gauge, disassemble, and place each segment separately on the jig. Hold each segment securely in place and fit the joints with fine sandpaper wrapped on a flat file or block. The face of the slot which runs through the center of the fitting jig is used as a guide for this operation. It is necessary that the entire length of file and block be covered with sandpaper to avoid damage to the guide surface of the fitting jig when using a file, and to prevent rocking. Remove sufficient carbon from the butts of segments to make the assembled ring too small to go over the gauge. After each joint has been refitted, the entire ring is reassembled with garter spring and placed on the fitting jig. The ring should be held against the bottom of the jig and turned by hand until the cutting edges of scribed marks have scraped out the bore sufficiently for the joints to butt. Remove the assembled ring from the jig and try on the gauge. If too small, replace on the jig and scrape. If the clearance is excessive, as checked by feelers, replace one segment on the jig and remove sufficient carbon from each butt to obtain the desired clearance. It is possible to make a jig and gauge to suit more than one bore of ring by pyramiding one size on another.

502-6.11.5 CARBON RING JIGS (FOR RINGS THAT RUB SHAFT). Some auxiliary steam turbines are fitted with rings which rub the shaft instead of having a clearance between the shaft and the ring as described in paragraph 502-6.11.2. For fitting rings on these units, the jig should be made so that its diameter, after scribing and including the height of the raised cutting edges, is the same as the shaft diameter. Rings cut on this jig should make contact with the shaft along the full length of each segment. Clearances should be provided between the butting ends of the segments. The total end clearance between the segments is usually about 0.152 mm (0.006 inch). This clearance is provided by filing ends of the segments as described in paragraph 502-6.11.4.

502-6.12 MAKING OF TURBINE CASING JOINTS

502-6.12.1 In the event that steam leakage is observed from around the turbine casing, the turbine should be disassembled, inspected, and repaired according to the applicable equipment technical manual or TRS. Extreme care must be taken in making a turbine casing joint. The joint surfaces should be carefully scraped and cleaned, then polished with crocus cloth. The joint faces should be carefully inspected for burrs and bruises. Never use sheet gasket material when remaking a high temperature steam casing joint unless specifically permitted in the applicable technical manual.

502-6.12.2 Turbine high pressure - high temperature joints may be made up by coating the surfaces with a thin layer of linseed oil and graphite, Copalite, or RTV-60. Opposite bolts should be set up fairly tight and then followed around until all are firmly secured. Gland joints are to be made in the same manner.

502-6.12.3 For additional information concerning turbine casing joints, consult the applicable equipment technical manual or NSTM Chapter 231, Propulsion and SSTG Steam Turbines.

502-6.13 REPAIR OF TURBINE BLADES AND WHEEL ROOT AREAS

502-6.13.1 If turbine blade inspection indicates damage to the blades or the blade root area and it is determined that replacement of the blade or repair to the blade root area is necessary, repairs should be accomplished only at the original equipment manufacturer. It is strictly prohibited to straighten turbine blades.

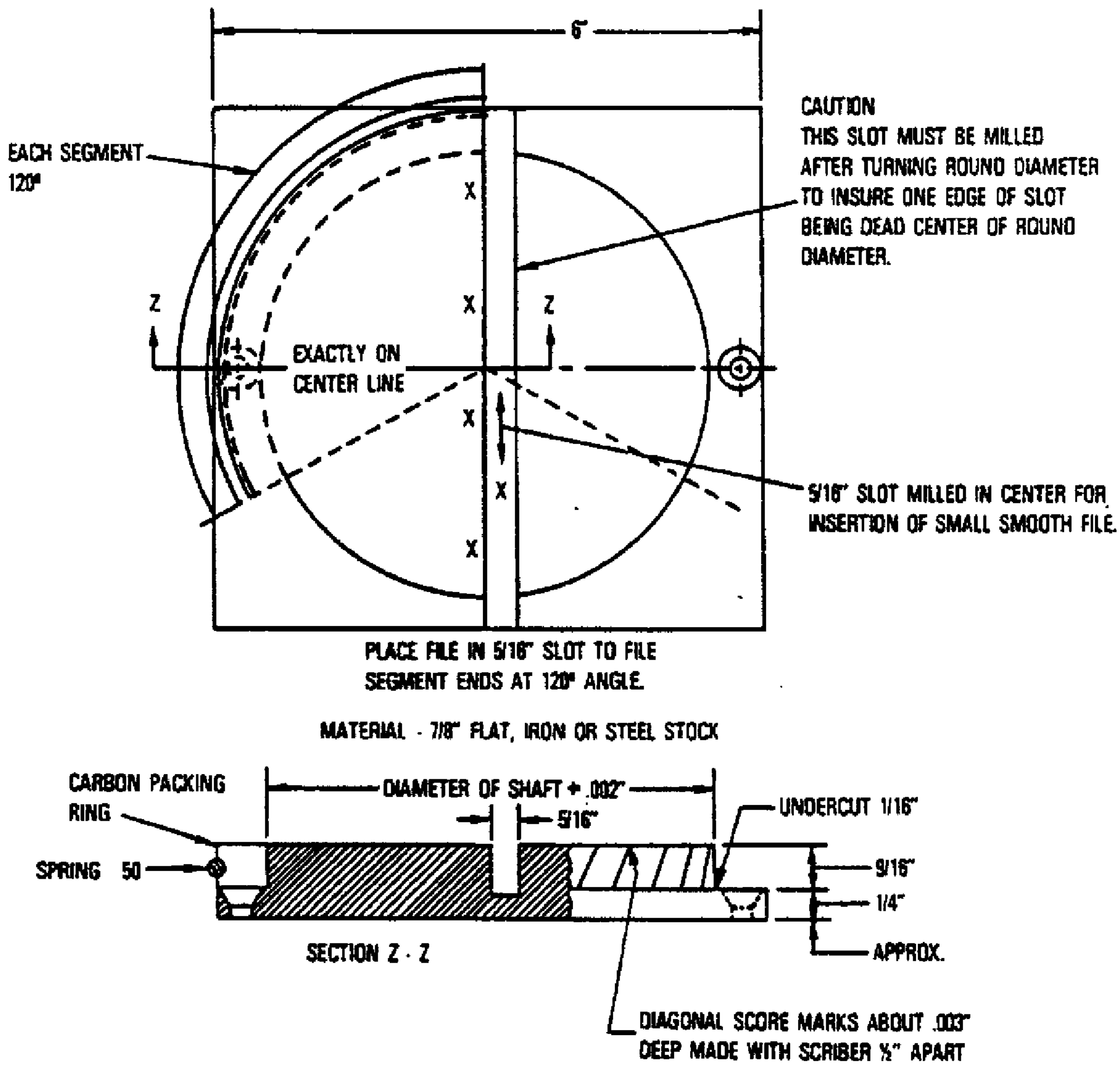

Figure 502-6-1 Carbon Ring Jig and Gauge

NOTE

The rotor assembly must be dynamically balanced following replacement of any rotating parts or removal of any metal by machining or grinding.

502-6.14 REPAIR OF TURBINE ROTOR/SHAFT

502-6.14.1 Repair of turbine rotors or shafts to return critical areas such as bearing journals and steam seal areas to original design dimensions can only be done by chrome plating in accordance with DOD-STD-2182, **Engineering Chromium Plating (Electrodeposited)** for repair of shafting, or thermal spray in accordance with MIL-STD-1678, **Thermal Spray Processes for Naval Ship Machinery and Ordnance Applications,** except that chromium plating is not permitted on stepped portions of a shaft. Weld repair is not permitted on turbine rotors or shafts.

502-6.15 GENERAL REFERENCE INFORMATION

502-6.15.1 For specific information concerning installation, disassembly, reassembly, clearances, set pressures, test procedures, or detail drawings for auxiliary turbines, refer to the applicable PMS procedures, TRS, or equipment technical manual.

REAR SECTION

NOTE

TECHNICAL MANUAL DEFICIENCY/EVALUATION EVALUATION REPORT (TMDER) Forms can be found at the bottom of the CD list of books. Click on the TMDER form to display the form.